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Problems in Prosthetics

SUMMARY

In the ever-evolving scientific world of medicine, prostheses continue to fulfill a necessary function. Modern aggressive management of such diseases as diabetes, stroke, and peripheral vascular disease has been matched by new technology and attitudes in the world of prosthetics. The final common denominator continues to be the patient. The problems patients have continue to be the focus of the Rehabilitation physician. (*Can Fam Physician* 1989; 35:309-312.)

Key words: prosthetics, amputation

RÉSUMÉ

Dans le monde scientifique médical où les changements sont constants, les prothèses continuent de répondre à un besoin fonctionnel. Au traitement contemporain agressif de maladies telles que le diabète, l'accident vasculaire cérébral et la maladie vasculaire périphérique s'ajoutent la technologie de pointe et les nouvelles attitudes de l'industrie prothétique. L'ultime dénominateur commun continue d'être le patient dont les problèmes demeurent au centre des préoccupations du spécialiste de la réadaptation.

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A SIGNIFICANT CHANGE has taken place in attitudes relating to patient suitability for prostheses. Problems that were previously thought to preclude prosthetic use are being actively rethought. Significant functional success is now achieved in the geriatric population. Most series have representative blind people as amputees. There is a more aggressive attitude towards the fitting of the hemiplegic amputee patient. Bilateral amputees are being made

functional walkers, depending on the level of their amputation, their age, and their desire for vertical posture. Double amputees are being fitted with arms and legs.

Careful medical and surgical attention to underlying disease processes is increasing the number of prosthetic candidates. Early diagnosis and ongoing management of such problems as depression, general debility, and contractures is producing an amputee-patient population better able to use prostheses. Early referral to a rehabilitation service with clear pre-prosthetic goals helps to ensure the patient's suitability for using a prosthesis. The patient's understanding of rehabilitation goals is also part of the treatment plan. Whether the patient is going to be a full prosthetic user or one with limited use is an important point to establish. Whether to try for independence of transfer or independent ambulation and living are im-

portant matters in setting a realistic goal for each patient.

This article will touch on many aspects of prosthetics and will focus on the problems patients have in adjusting to their use. The text will deal mainly with lower-limb amputees, as patients in this category represent the majority of prosthetic users. A bibliography of supplementary reading is included at the end of this article.

Problems with Patients: Host, Health and Hopes

Expectations differ with each age category of amputee. The young want to know if they can run, and the old want to know if they will be able to get out of a wheelchair and achieve a useful level of independent function.

A number of issues should be addressed in the assessment of a patient's capability to use prostheses. The patient's capacity to learn is im-

portant, and this can readily be ascertained in the day-to-day work with the therapist. If a patient has been ill from trauma or debilitating disease, it is important to establish a general level of physical ability, such as sitting tolerance and standing tolerance, and to establish a level of activity that is consistent with prosthetic training. Balance and endurance are both areas which should be assessed and addressed in a prosthetic program. The question of pain, be it central or peripheral, may require special therapeutic techniques. Wound healing of the stump must also have reached a manageable level before a prosthesis can be considered.

More specifically, the patient's cardiac and respiratory reserve is important. Previous myocardial infarctions, hypertension, heart disease, or chronic obstructive pulmonary disease all may limit the patient's exercise tolerance and therefore the ability to pursue a prosthetic program. Even if the patient is considered fit, such a history may influence the speed at which their program may progress.

Diabetes presents a major concern in this population. The presence of peripheral neuropathy in the amputee may influence the manual dexterity required for putting the limb on, as well as decreasing kinesthetic feedback from the intact limb for balance and posture. Retinopathy or cataracts may impair vision, a limitation that may critically alter the patient's ability to put on the limb as well as decrease visual balance clues necessary in ambulation.

In peripheral vascular disease of any etiology, it is important to determine and document the status of the other limb, including ischemic pain, exercise tolerance, skin quality, and the presence of infection.

When the patient has had a stroke the function in the hemiplegic side should be documented. The function really must be of a level that would have been commensurate with ambulation in the absence of amputation before this patient can be expected to use a prosthesis successfully. Whether the amputation is on the hemiplegic side or on the opposite side, and whether the amputation is above or below the knee are also important points in determining whether a prosthetic

thesis will produce a successful walker.

Ongoing back pain, whether osteoarthritic or neurogenic, may preclude prolonged sitting or standing and thus preclude or modify a prosthetic training program.

Problems with the Amputee Stump: Concerns and Considerations in Care

Among other early problems, it is important to review with the surgeon the planned length of a patient's stump, to determine whether or not an internal prosthetic joint, such as a knee, can be incorporated in the prosthesis and still match the joint levels of the remaining limb. A distal weight-bearing stump may well be a consideration with lower limb amputations. In children the growth potential of the stump in the epiphyseal areas must be considered even at the cost of planning a revision after skeletal maturity. Vascular bypass scars with grafting underlying areas that will be encountering prosthetic pressure should be considered. Fracture alignment should be taken into consideration in order to optimize stump shape. Finally, the function of the joint, especially in a traumatic amputation, should be carefully considered. A fracture into a joint, resulting in a compromised joint and consequent short scarred stump may have greater disadvantages than advantages in some situations.

Stump bandaging and stump shrinking techniques are important for optimum stump shaping. Incorrect bandaging leads to an incorrect stump contour and subsequent difficulty in fitting a prosthesis. Poor resting postures and the lack of a physiotherapy program will result in flexion contractures at the knee and hip, as will simple prolonged bed rest. These are avoidable complications.

The general power and function of the stump should be assessed early and a program designed for it. The problem of phantom sensation should be discussed with the patient, along with the unusual phenomena of telescoping stump images, so that the patient will have some understanding of these matters. The question of phantom pain is also a difficult one that requires patient knowledge and agreement in management. Narcotic

medications virtually never work in this situation, but a well-fitting prosthesis with a lot of support and perhaps the judicious use of antidepressants often leads to function.

In those stumps with delayed healing the status of the wound and the underlying bone must be assessed and a decision made as to whether fitting should be postponed or can be aggressively pursued. Isolating the healing area from weight bearing but yet encouraging fitting and ambulation has a very positive effect on healing in the dysvascular amputee. At the same time, it also improves the patient's general health and well-being and relieves depression.

Pain that progresses with exercise, decreases with rest, and is not related to the prosthetic fit may be ischemic in nature. Consultation with the vascular surgeon for diagnosis and management is necessary.

Unusual wear spots in the stump, adductor rolls at the groin, and chronic skin infections are all local problems that require education and attention on the part of the physician, the prosthetist, and the patient. Clean skin, avoidance of lotions, and a properly fitting prosthesis minimize these problems. For those patients who sweat excessively, regular changing of stump socks through the day often minimizes any skin irritation and breakdown.

Problems with the Prosthesis: Measurements, Movement and Myoelectrics

There are several general observations to be made about the prosthesis itself. The timing of initial prosthetic fitting must be considered in relation to the general condition of the patient and the condition of the stump. The stump should be shrunk to a shape that allows identification of the anatomical contours. Two to three weeks of stump bandaging are usually necessary to accomplish this. At this time a first-fit socket can be made, and the patient will have the double advantage both of being able to be up and walking, and of being able to shrink the stump more specifically by means of the first-fit socket.

Children with growth potential must be checked regularly, as they tend to grow out of their sockets. Socket fit is a time-consuming and expensive business that must be pro-

spectively planned for. Patients with double amputations usually have their lower limb amputation site fitted first and then the upper extremity amputation fitted. Bilateral amputees may have had a previous amputation. If so, this previous amputation site should be carefully checked for prosthetic fit. As soon as such patients are able to stand on the one leg, the second prosthesis may be fitted and gait training initiated. Depending on their fitness and determination it may be possible successfully to fit a bilateral above-knee amputee for ambulation. There is more likelihood of fitting an above-knee and below-knee amputee, and it is almost always possible to fit a double below-knee amputee when the patient has been previously ambulant on a single prosthesis.

The length of a prosthetic leg may be a practical problem. Usually the below-knee amputees are fitted with a prosthetic leg length equal to the unaffected limb. Above-knee amputees, because of the difficulty in clearing the toe, may well be fitted with a prosthesis a half-inch to an inch short, depending on their agility, the type of foot they have, and the kind of ground they have to travel. Leg-length inequality may lead to a poor gait and chronic low-back pain.

More specific problems with the prosthesis are addressed in deciding the best components for the amputee. The above-knee weight-bearing principles can be met by casting a quadrilateral socket which takes weight on the ischial seat. A more modern CAT-CAM (contoured adducted trochanteric controlled alignment method) concept tends to trap the trochanter of the femur and the ramus of the pubis and in so doing provides good medial-lateral stability at the cost of technician time in fitting. Other design options may be a rigid socket, which provides more strength and durability, as compared to the flexible socket, which theoretically provides better muscle control.

Suction-socket suspension is ideal in the above-knee amputation. However the ideal may have to be tempered in dealing with an older patient who has poor balance and who is unable to pull the socket on. The traditional design of hip joint and pelvic belt may offer lateral stability or at least the feeling of lateral stability in the older patient, be more comfort-

able, be more forgiving, and allow greater ease in getting the limb on and off. Silesian bandages, shoulder harnesses, and other elastic devices also can be complementary to these two systems.

The prosthetic knees available for the above-knee amputee provide varying degrees of sophistication, from hydraulic function through to a simple constant friction design. The endoskeletal or exoskeletal safety knee is an attractive concept, as it allows for knee stability at heel strike even when the knee is in slight flexion. This provides a clear advantage for the hesitant geriatric ambulator.

The patellar tendon-bearing socket design for the below-knee amputee has made an enormous difference in the function of that category of amputee. Side-irons and corsets are still used for weight relief and stability for patients with short painful stumps or those engaged in manual occupations. Modifications of the patellar tendon-bearing socket with supracondylar and suprapatellar flares allow for an excellent degree of stability of even short stumps.

Single-axis ankles and multi-axis ankles are not new to the market. However what is new and exciting is the dynamic, as compared to the older static, design of foot. A compressible spring device in the foot and/or shin portion of the prosthesis provides an extra push at toe-off, which improves the prosthetic gait and increases endurance. With the expensive but impressive Flex foot, because of the kind of energy stored and then transmitted, excellent socket fit is essential, or stump skin problems, gait abnormalities and knee pain may result. This design seems to be at the cutting edge of technology for the active and athletic below-knee amputee.

Myoelectrics represent today's technology. Enthusiastic centres fit many of these and have the necessary back-up to guarantee their users' training. In any centre there are selected amputees who will do well with a myoelectric prosthesis. The below-elbow amputee who is not doing heavy work is an ideal candidate. With a high above-elbow amputee, microswitching sometimes allows a greater degree of control. More often, because of the weight and com-

plexity of such a unit, it is rejected for a manually operated prosthesis. A passive sleeve filler may be preferred when the other upper limb is unaffected.

Problems with Function: Dynamics, Difficulties and Determination

The ability of a patient to get a leg on or off quickly is important in the convenience and safety of its use. Stability must be provided for uneven ground walking, as well as the ability to climb stairs. Ambulatory assistive devices may well have to be considered. A cane or canes is/are often sufficient for balance and security. Prosthetic wearers may choose crutches as assistive devices when stump pain or back pain is a significant problem. In these situations forearm crutches are the most practical. Many above-knee geriatric walkers are most secure when using a walker. By so doing they are able to be independent but confident at the same time.

The study of gait in the amputee is a topic in itself. Static alignment is important in terms of biomechanical efficiency of the low back and opposite limb. For instance, if the prosthetic leg is too long, it will be held away from the midline. It may also be held in abduction because of groin pain. Poor training may result in vaulting on the unaffected side to clear the affected side, which is a highly energy-expensive gait. Side-flexion over the prosthetic device is a gait created for stabilization and often results in fatigue and low-back pain. Specific prosthetic problems such as prolonged time at foot flat or ineffective toe-off are usually prosthetic alignment problems. Heel whips, either medial or lateral, also suggest poor alignment and should be reviewed with the physician and prosthetist.

A knee that cannot be properly locked when at the foot-flat position may well be caused by a hip-flexion contracture which biomechanically limits the patient's ability to do this. Such flexion contractures should be sought out early and dealt with. The patient may often mask a significant hip-flexion deformity by increased lumbar lordosis, but when it comes to using a prosthesis, this inability to get

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INDICATIONS: Prevention or relief of bronchospasm due to bronchial asthma, chronic bronchitis and other chronic bronchopulmonary disorders in which bronchospasm is a complicating factor.

CONTRAINDICATIONS: Hypersensitivity to any of the ingredients and tachyarrhythmias. Not recommended for children under two years of age, until the dose regimen and evidence concerning its safety have been established.

WARNINGS: Safety of salbutamol in pregnancy and in lactation has not been established. Care should be taken with patients suffering from myocardial insufficiency, arrhythmia, hypertension, diabetes mellitus or thyrotoxicosis.

PRECAUTIONS: Should be used with caution in patients sensitive to sympathomimetic amines. Concomitant use with other oral sympathomimetic agents is not recommended since such combined use may lead to deleterious cardiovascular effects. Ventolin Oral Liquid should be administered with caution to patients being treated with monoamine oxidase inhibitors or tricyclic antidepressants since the action of salbutamol on the cardiovascular system may be potentiated. Beta-adrenergic blocking drugs, especially the non-cardioselective ones, may effectively antagonize the action of salbutamol.

ADVERSE REACTIONS: The most frequent are nervousness and tremor. Headache, tachycardia, palpitations, muscle cramps, insomnia, nausea, weakness, and dizziness have also been reported. Other rare adverse reactions have been drowsiness, flushing, restlessness, irritability, chest discomfort, difficulty in micturition, hypertension, angina, vomiting, vertigo, central stimulation, unusual taste, and drying or irritation of the oropharynx.

SYMPTOMS AND TREATMENT OF OVERDOSAGE: Overdosage may cause peripheral vasodilation and increased irritability of skeletal muscle, hypokalemia, tachycardia, arrhythmia and hypertension. In case of overdosage, gastric lavage should be performed. In order to antagonize the effect of salbutamol, the use of a beta-adrenergic blocking agent, preferably one of the relatively cardioselective ones (e.g. metoprolol, atenolol) may be considered.

DOSAGE AND ADMINISTRATION: Adults and children over 12 years of age should take 5 to 10 mL (2 to 4 mg) three to four times daily. Children between 6 and 12 years of age should take 5 mL (2 mg) three to four times daily. For children aged 2 to 6 years a dose of 0.25 mL (0.1 mg) per kg body weight may be given three to four times daily. Safety and efficacy in children under 2 years of age have not been established.

When prescribing Ventolin Oral Liquid, the patient should be advised that the action of this medication may last for 6 to 8 hours and therefore it should not be taken more frequently than recommended. There should be no increase in dose or frequency without medical consultation. The doctor must be contacted promptly if symptoms worsen.

AVAILABILITY: Ventolin Oral Liquid is a clear, colourless, orange-flavoured liquid containing 0.4 mg salbutamol (as the sulphate) per mL. Available in bottles of 250 mL.

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PAAB

the hip into neutral or extension becomes a critical problem.

The bottom line in function is a nice balance between safety and energy consumption. Walking with an above-knee prosthesis is roughly equated in energy consumption to a normal vertical patient going briskly up the stairs. This fact, combined with a bit of prosthetic knee instability, may compromise the older patient's ability to function. However, in her wisdom, Mother Nature usually simply slows this patient down to a point where the person's energy requirements are acceptable and safety more assured.

The younger generation cannot wait for the prosthetic function to match their speed, and a gait such as that displayed by Terry Fox is adopted as the quickest way of getting around at a significant energy cost — but they can afford the bill.

The desire of the patient to ambulate regularly and consistently, as well as independently, will be the most telling factor in the overall success rate. There are many patients who are ambulant, employed and content with a prosthesis which, when reviewed, is judged to be far from ideal. There are patients, too, who have state-of-the-art technology in their prosthesis but await the magic of determination to become a prosthetic user. A team approach with an informed and concerned physician directing the effort to meet the patients' special needs will often provide the necessary support for the hesitant or apprehensive patient in his or her bid for ambulatory independence.

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